Effects of Episodic Events on the Transport of Nutrients to the Gulf of Mexico

D. A. Goolsby and W. A. Battaglin
U.S. Geological Survey
Water Resources Division
Denver, Colorado

Abstract

Nutrients (nitrogen and phosphorus) derived from areas of intense agriculture in the upper Mississippi River basin have been implicated as the indirect cause of oxygen depletion (hypoxia) in the Gulf of Mexico along the Louisiana–Texas coast. The largest influx of nutrients to the Gulf typically occurs each year during the spring and early summer when streamflow and concentrations of nutrients, such as nitrate, are highest. During extreme high flow episodes, such as the 1993 flood in the upper Mississippi River, abnormally large amounts of nitrate and other nutrients are transported into the Gulf. During April through September 1993, for example, the nitrate flux to the Gulf was more than 900,000 metric tons (as N). This is 100 percent more nitrate than was discharged to the Gulf during this same period in 1992 and 1994, and 50 percent more than in 1991 and 1995. While these episodic events cause considerable year-to-year variation in flux of nutrients, there is evidence that annual fluxes also have increased. An analysis of historical water chemistry data collected at St. Francisville, Louisiana and Baton Rouge, Louisiana since 1954 shows that the concentration and flux of nitrate in water discharged to the Gulf has increased about threefold, with most of the increase occurring since 1968. Conversely, the concentration and flux of total phosphorus has changed little since 1973 when the first phosphorus records were collected.

The principal areas contributing nutrients to the Mississippi River and ultimately the Gulf of Mexico are streams draining the corn belt states, particularly Iowa, Illinois, Indiana, Ohio, and southern Minnesota. About 60 percent of the nitrate transported by the Mississippi River is derived from less than 20 percent of the basin. Current sources of nitrogen for the Mississippi River basin, in decreasing order of their input include commercial fertilizers, animal manures, legumes, municipal and domestic wastes, and atmospheric deposition. The present use of nitrogen fertilizer in the basin is estimated to be about 6.6 million metric tons per year and accounts for more than one-half the annual nitrogen input.

No Manuscript Submitted.

Presentation Discussion

Don Goolsby (U.S. Geological Survey—Lakewood, CO)

Len Bahr *(Louisiana Governor's Office– aton Rouge, LA)* congratulated the U.S. Geological Survey on presenting excellent information and he added that it was the type of information that

was needed. He continued by wishing the USGS well on receiving their budget from Congress. He said he was an ecologist, not a soil scientist or an agricultural person, and felt that the information presented was good news. There is an enormous potential for cost savings in nitrate fertilizer application and it certainly appeared that changes in fertilizer use and application could be achieved.

Don Goolsby asked if someone was present from the Department of Agriculture, because he wanted a representative to comment on Len Bahr's statement. He said he knew the Department of Agriculture conducts many programs through which they attempt to account for the nitrogen already in the soil and give credit for that; applying less nitrogen in current years. His understanding was that these programs were working to some degree, and attributed some of the leveling in contributions to those efforts.

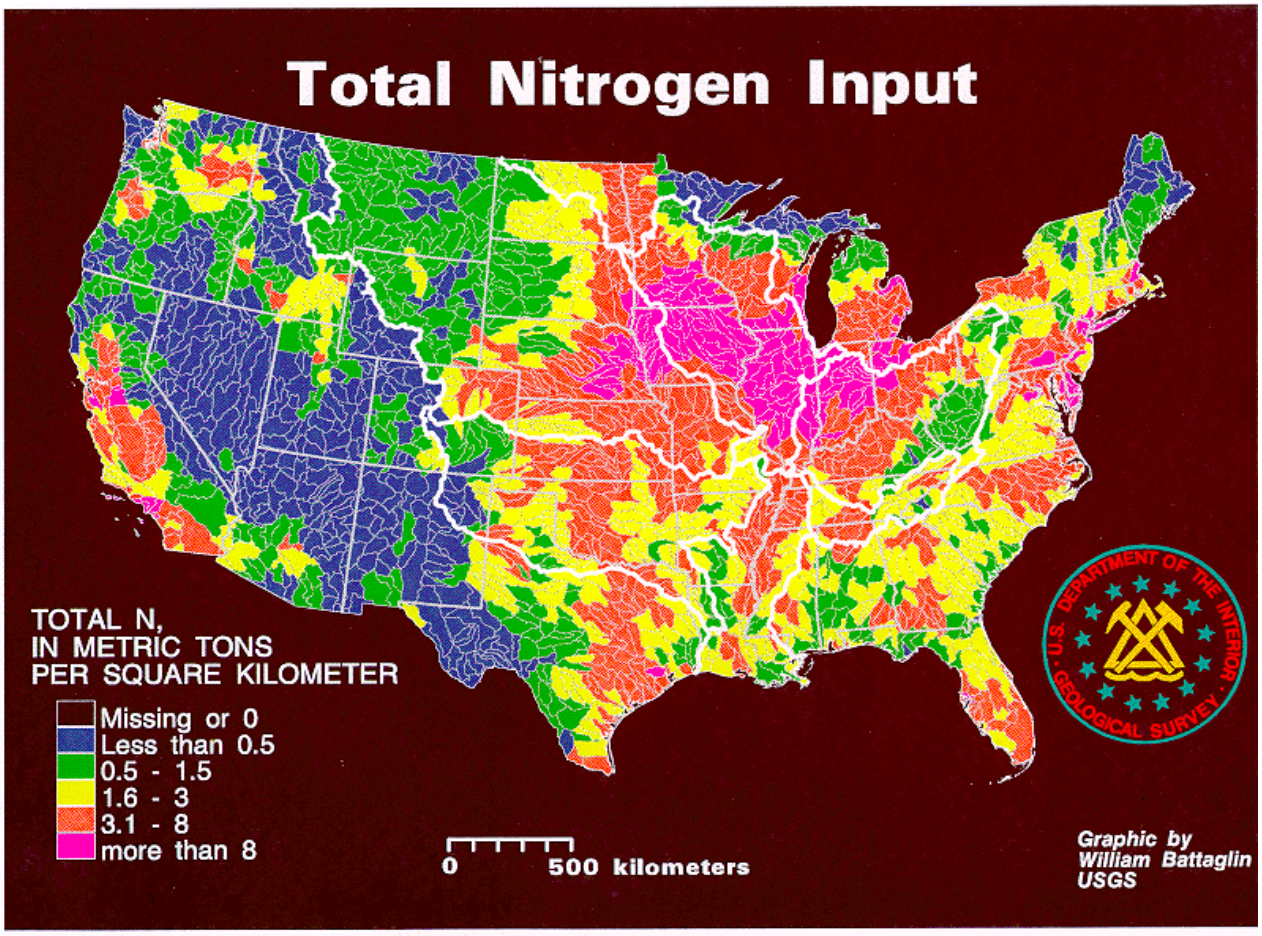
Eugene Turner *(Louisiana State University—Baton Rouge, LA)* asked two questions:

- Is some double accounting of manure inputs and fertilizer application.

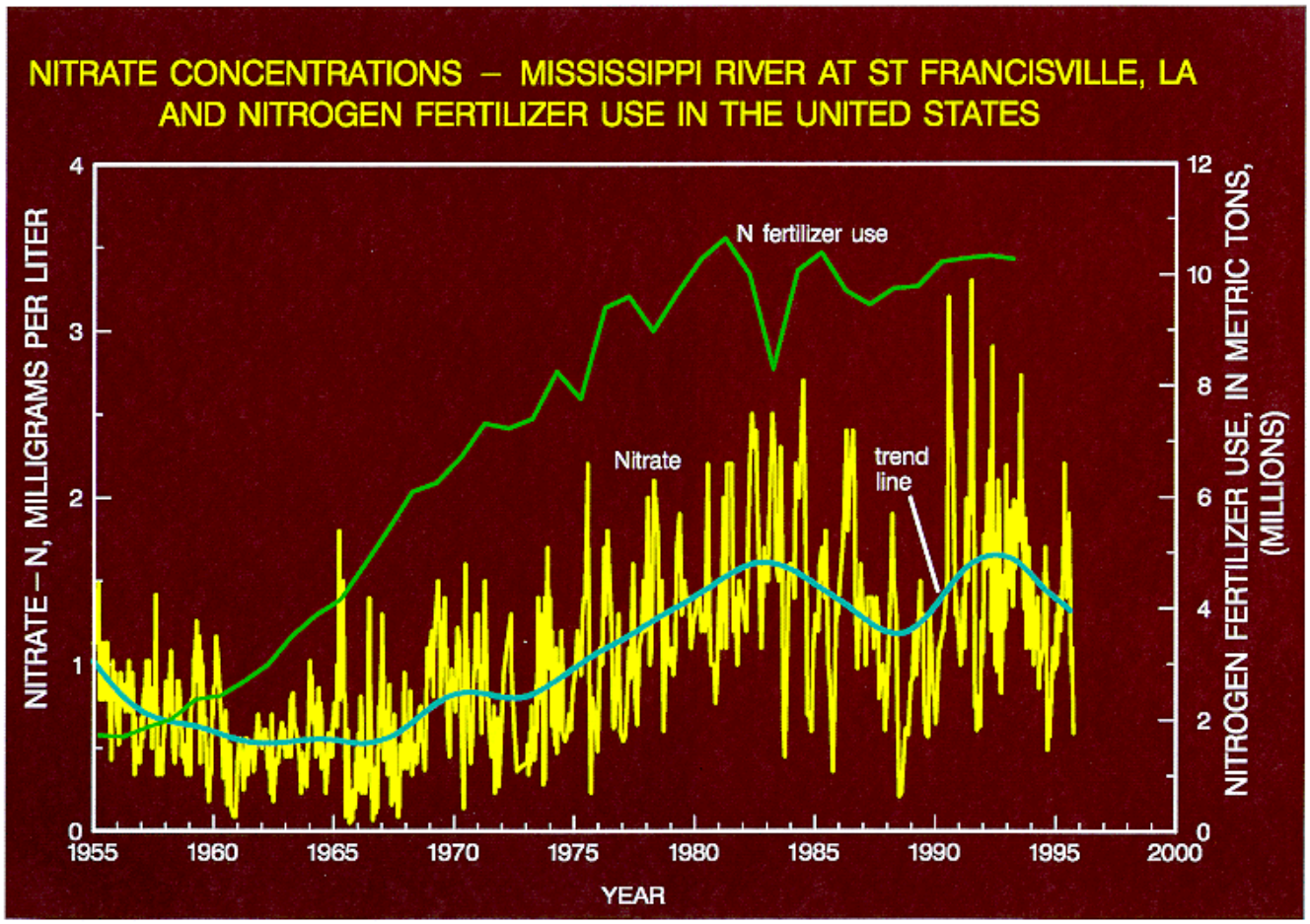
- Secondly, he questioned if anything can be done to improve sampling at the national water quality stations. He cited that some of those stations are sampled only six or eight times a year.

Don Goolsby responded to the first question by saying that there is some double accounting of manure inputs because the fertilizer produces feed that the animals use.

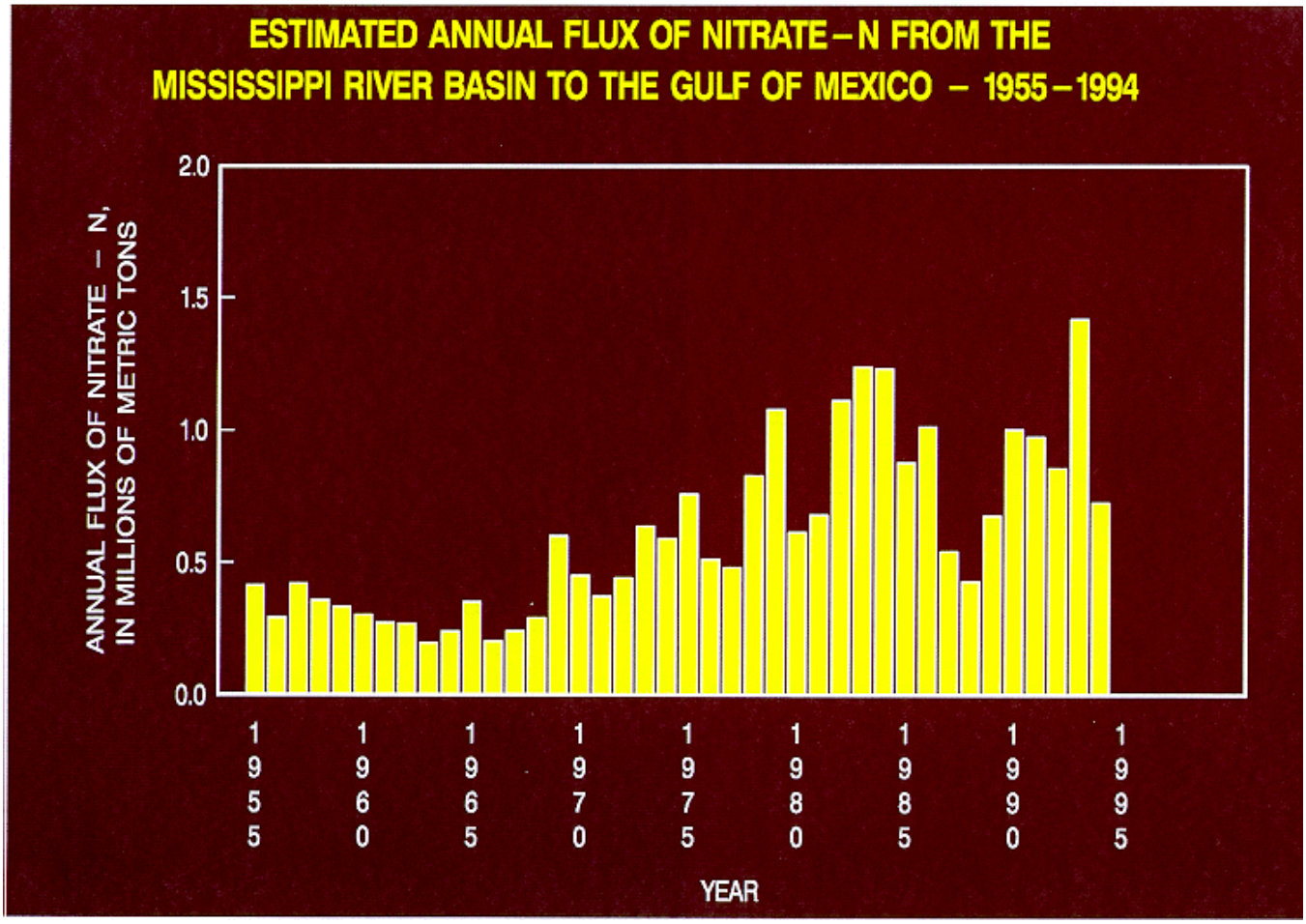
In response to Eugene Turner's second question, Don Goolsby said that he had mentioned that the NAWQA network was being redesigned. The sampling frequency will be doubled or tripled over the past frequency, but the number of stations will be reduced to 30 or 40 nationwide and will be focused in four large river basins.



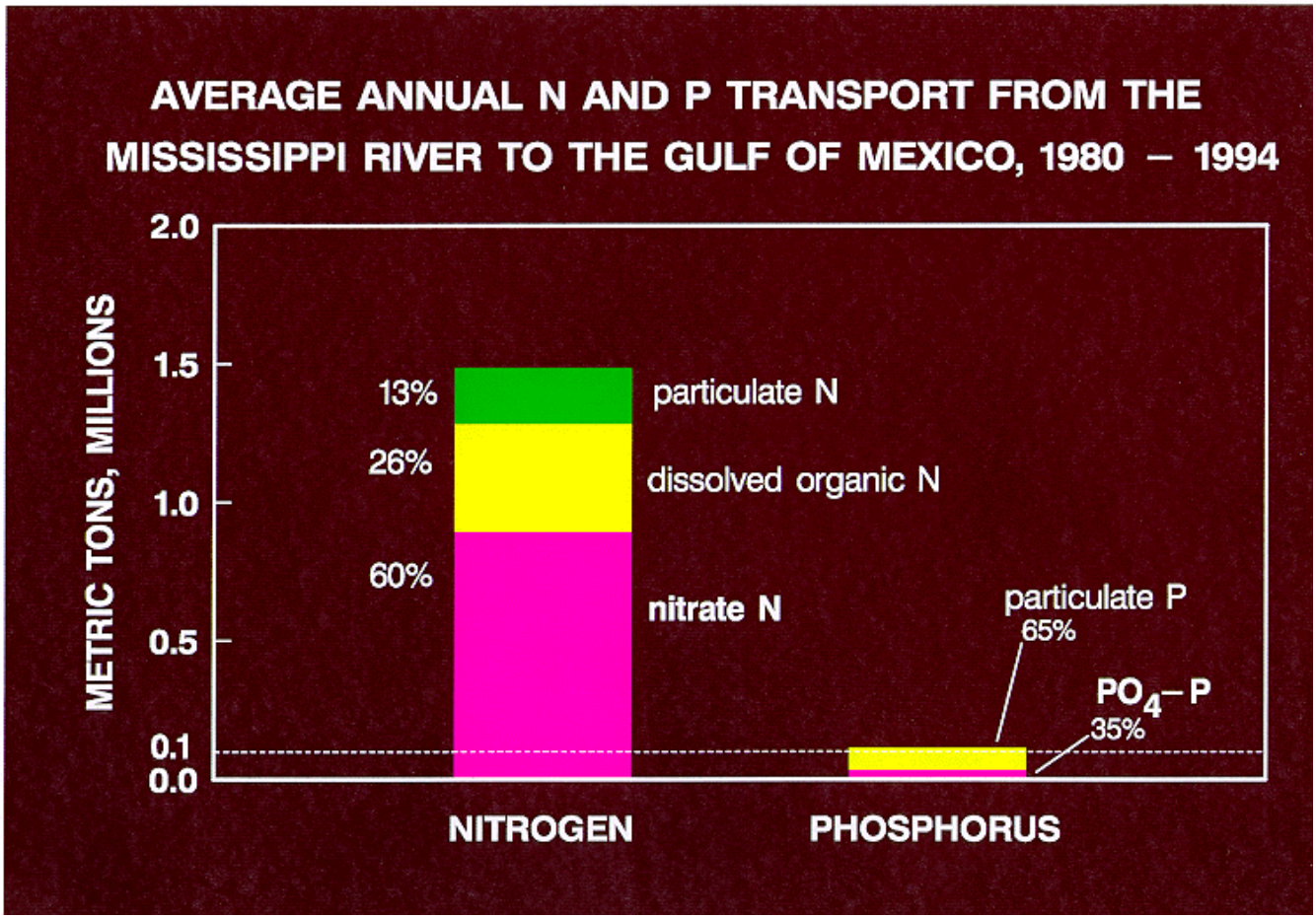
The input of nitrogen to the Mississippi River Basin is estimated to be more than 11 million metric tons (t) per year based on agricultural census data collected during 1987-92. The major sources of nitrogen in decreasing order in input are: commercial fertilizer, 6.3 million t; animal manure, 2.8 million t; legumes (net input) 1.1 million t; domestic and municipal waste 0.6 million t; and atmospheric deposition, 0.5 million t. The inputs of nitrogen are largest in the upper basin states of Illinois, Iowa, Indiana, Minnesota, Ohio, and Nebraska (see graphic).



Long-term records collected by the U.S. Geological Survey show that the nitrate-nitrogen concentrations in the lower Mississippi River have doubled since 1960. During this same period of time the use of nitrogen fertilizer has quadrupled. Nitrate concentrations generally are highest during late winter and spring when streamflow is highest and lowest in autumn when flows are lowest.



The flux of nitrate-nitrogen from the Mississippi River Basin to the Gulf of Mexico has increased from about 320,000 metric tons per year during the period 1955-1969 to nearly 900,000 metric tons per year for the period since l980. The largest annual flux is associated with high flow years such as the 1993 flood year when more than 1.4 million metric tons of nitrate-N were discharged to the Gulf.



The average annual transport of nitrogen in all forms (total N) from the Mississippi River Basin to the Gulf of Mexico is about 1.5 million metric tons per year, based on data collected since 1980. Nitrate-N accounts for about 60 percent of the total N transport. The remainder is dissolved organic N (about 26%) and particulate N (about 13%). The average total phosphorus transport to the Gulf is about 110,000 metric tons per year, of which about 35 percent is dissolved orthophosphate. The remaining 65 percent is primarily in particulate form. Nitrate and orthophosphate are readily available for uptake by biota. A portion of the organic and particulate N and P fractions also can become available to biota through various chemical and micro-biological processes.